CLAIMS

1. A liquid crystal alignment film, which is a film wherein a silane-based surfactant having a linear carbon chain and Si is chemically adsorbed via an energy beam sensitive resin film for generating functional groups containing active hydrogen by energy beam irradiation formed on a predetermined surface of a substrate, where the linear carbon chains are aligned in a specific direction.

2. The liquid crystal alignment film according to claim 1, wherein the film formed of the surfactant is fixed to the energy beam sensitive resin film via covalent bonds on the surface of the substrate in a striped pattern.

3. The liquid crystal alignment film according to claim 2, wherein the fixed film formed of the surfactant is fixed to the energy beam sensitive resin film via a film having siloxane bonds.

4. The liquid crystal alignment film according to any one of claims 1 to 3, wherein the silane-based surfactant is a chlorosilane-based surfactant containing a linear hydrocarbon group and a chlorosilyl group.

5. The liquid crystal alignment film according to claim 4, wherein a part of hydrogen of the linear hydrocarbon group of the chlorosilane-based surfactant is substituted with at least a fluorine atom.

6. The liquid crystal alignment film according to claim 4 or 5, wherein a plurality of types of chlorosilane-based surfactants, each having a different molecular length, are mixed and used as the chlorosilane-based surfactant containing a linear hydrocarbon group and a chlorosilyl group.

7. A liquid crystal alignment film, which is a monomolecular film formed on a surface of a substrate provided with desired electrodes, wherein the molecules constituting the film have a desired tilt and are bonded and fixed to the surface of the substrate at one end while being aligned uniformly in a specific direction.

8. The liquid crystal alignment film according to claim 7, wherein the desired tilt of the molecules is defined by fixing the molecules constituting the film to the substrate by covalent bonds, washing the molecules with an organic solvent, and tilting the substrate in a desired direction so as to drain off the solvent.

9. The liquid crystal alignment film according to claim 7 or 8, wherein the molecules constituting the film contain carbon chains or siloxane bond chains.

10. The liquid crystal alignment film according to claim 9, wherein a carbon of a

part of the carbon chain has an optical activity.

11. The liquid crystal alignment film according to any one of claims 7 to 10, wherein the molecules constituting the film have Si at both ends.

12. The liquid crystal alignment film according to any one of claims 7 to 11, wherein the molecules constituting the film are formed by mixing a plurality of types of chemisorption molecules having different molecular lengths, and the fixed film has concavities and convexities on a molecular length level.

13. A liquid crystal alignment film, which is a monomolecular film formed on a surface of a substrate provided with desired electrodes, wherein the molecules constituting the film have carbon chains or siloxane bond chains, and at least a part of the carbon chain or the siloxane bond chain contains at least a functional group for controlling a surface energy of the film.

14. The liquid crystal alignment film according to claim 13, wherein a plurality of types of silane-based surfactants, each having a different critical surface energy, are mixed and used as the molecules constituting the film, and the fixed film is controlled so as to have a desired critical surface energy.

15. The liquid crystal alignment film according to claim 13 or 14, wherein the functional group for controlling the surface energy is at least one organic group selected from the group consisting of a carbon trifluoride group ($-CF_3$), a methyl group ($-CH_3$), a vinyl group ($-CH=CH_2$), an allyl group ($-CH=CH-$), an acetylene group (triple bonds of carbon – carbon), a phenyl group ($-C_6H_5$), an aryl group ($-C_6H_4-$), a halogen atom, an alkoxy group ($-OR$; R represents an alkyl group), a cyano group ($-CN$), an amino group ($-NH_2$), a hydroxyl group ($-OH$), a carbonyl group ($=CO$), an ester group ($-COO-$) and a carboxyl group ($-COOH$).

16. The liquid crystal alignment film according to any one of claims 13 to 15, wherein the molecules constituting the film contain Si at the terminals.

17. The liquid crystal alignment film according to any one of claims 13 to 16, wherein the critical surface energy of the film is controlled to be a desired value between 15 mN/m to 56 mN/m.

18. A liquid crystal alignment film, wherein a resin film transparent in visible light range and having energy beam sensitive groups and thermoreactive groups is formed directly on electrodes or indirectly via an arbitrary thin film, and at least the energy beam sensitive groups are reacted and crosslinked.

19. The liquid crystal alignment film according to claim 18, wherein the energy

beam sensitive groups and the thermoreactive groups are introduced as side chain groups in the resin film.

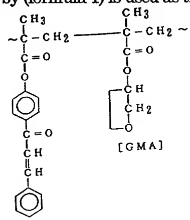
20 The liquid crystal alignment film according to claim 18, wherein the energy beam sensitive groups, the thermoreactive groups and hydrocarbon groups are introduced as side chain groups in the resin film.

21. The liquid crystal alignment film according to claim 18, wherein the surface of the resin film has striped concavities and convexities.

22. The liquid crystal alignment film according to any one of claim 18 to 21, wherein the thermoreactive groups are reacted and crosslinked.

23. The liquid crystal alignment film according to claim 18, wherein a substance represented by (formula 1) is used as the resin film.

(formula 1)



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24. A method for producing a liquid crystal alignment film comprising the steps of applying and forming an energy beam sensitive resin film for generating functional groups containing active hydrogen by energy beams directly or indirectly via an arbitrary thin film on a predetermined surface of a substrate provided with electrodes, irradiating the surface of the resin film with energy beams in an arbitrary pattern, contacting the irradiated resin film with a chemisorption solution containing a silane-based surfactant having linear carbon chains and Si groups, washing the substrate with a solvent incapable of dissolving the resin film, thereby forming one layer of a monomolecular film formed of the surfactant selectively in the irradiated portion, and aligning and fixing the linear carbon chains in the surfactant molecules.

25. The method for producing a liquid crystal alignment film according to claim 24, wherein the energy beams are at least one light selected from the group consisting of electron beams, X rays or light with a wavelength of

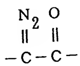
100 nm to 1 μm.

26. The method for producing a liquid crystal alignment film according to claim 25, wherein the chemisorption solution contains at least a chlorosilane-based surfactant comprising a linear carbon chain and a chlorosilyl group and a solvent that causes no damage to the energy beam sensitive resin film.

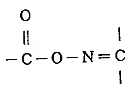
27. The method for producing a liquid crystal alignment film according to claim 25 or 26, wherein the energy beams are at least one light selected from the group consisting of ultraviolet rays, visible rays and infrared rays, and the energy beam sensitive resin film is a photosensitive resin film.

28. The method for producing a liquid crystal alignment film according to claim 27, wherein the photosensitive resin film is a polymer film or a monomer film containing at least one organic group selected from the group consisting of a group represented by (formula 2), a group represented by (formula 3) and a group represented by (formula 4).

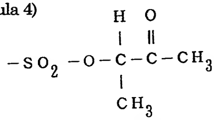
(formula 2)



(formula 3)



(formula 4)



29. The method for producing a liquid crystal alignment film according to any one of claims 24 to 28, wherein a solvent including a carbon fluoride group is used as a nonaqueous solvent.

30. A method for producing a monomolecular liquid crystal alignment film comprising the steps of contacting a substrate provided with electrodes with a

chemisorption solution so as to cause a chemical reaction between molecules of a surfactant in the adsorption solution and a surface of the substrate, thereby bonding and fixing the surfactant molecules to the surface of the substrate at one end, washing the substrate with an organic solvent, and tilting the substrate in a desired direction so as to drain off the solvent, thereby aligning the fixed molecules in the direction in which the solvent was drained off.

31. The method for producing a monomolecular liquid crystal alignment film according to claim 30 further comprising the step of exposing the substrate to light polarized in a desired direction via a polarizing plate after the step of aligning the molecules, so as to align the orientations of the surfactant molecules uniformly in a specific direction at a desired tilt.

32. The method for producing a monomolecular liquid crystal alignment film according to claim 30 or 31, wherein a silane-based surfactant containing linear hydrocarbon groups or siloxane bond chains and chlorosilyl groups, alkoxysilyl groups or isocyanate silyl groups is used as the surfactant.

33. The method for producing a monomolecular liquid crystal alignment film according to claim 32, wherein a plurality of types of silane-based surfactants, each having a different molecular length, are mixed and used as the silane-based surfactant containing linear hydrocarbon groups or siloxane bond chains and chlorosilyl groups, alkoxysilyl groups or isocyanate silyl groups.

34. The method for producing a monomolecular liquid crystal alignment film according to claim 32 or 33, wherein a carbon of a part of the hydrocarbon group has an optical activity.

35. The method for producing a monomolecular liquid crystal alignment film according to any one of claims 32 to 34, wherein the hydrocarbon group or the siloxane bond chain contains a halogen atom or a methyl group ($-CH_3$), a phenyl group ($-C_6H_5$), a cyano group (-CN), a hydroxyl group (-OH), a carboxyl group (-COOH), an amino group ($-NH_2$), or a carbon trifluoride group ($-CF_3$) at the terminal.

36. The method for producing a monomolecular liquid crystal alignment film according to claim 31, wherein light that is used for exposure is light having at least one wavelength selected from the group consisting of 436 nm, 405 nm, 365 nm, 254 nm and 248 nm.

37. The method for producing a monomolecular liquid crystal alignment film

according to any one of claims 32 to 36, wherein a silane-based surfactant containing linear hydrocarbon groups or siloxane bond chains and chlorosilyl groups or isocyanate silyl groups is used as the surfactant, and a nonaqueous organic solvent containing no water is used as the washing organic solvent.

38. The method for producing a monomolecular liquid crystal alignment film according to claim 37, wherein a solvent containing an alkyl group, a carbon fluoride group or a carbon chloride group or a siloxane group is used as the nonaqueous organic solvent.

39. The method for producing a monomolecular liquid crystal alignment film according to any one of claims 30 to 38, wherein a film containing a large number of SiO groups is formed before the step of fixing the surfactant molecules at one end, and then a monomolecular film is formed via this film.

40. A method for producing a monomolecular liquid crystal alignment film comprising the steps of contacting a substrate provided with electrodes with a chemisorption solution produced by using a silane-based surfactant containing carbon chains or siloxane bond chains, at least a part of the carbon chain or the siloxane bond chain containing at least one functional group for controlling a surface energy of a formed film, thereby causing a chemical reaction between the surfactant molecules in the adsorption solution and the surface of the substrate so as to bond and fix the surfactant molecules to the surface of the substrate at one end.

41. The method for producing a monomolecular liquid crystal alignment film according to claim 40, wherein a silane-based surfactant containing linear carbon chains or siloxane bond chains and chlorosilyl groups, alkoxysilyl groups or isocyanate silyl groups is used as the surfactant.

42. The method for producing a monomolecular liquid crystal alignment film according to claim 40 or 41, wherein a plurality of types of silicon-based surfactants having different critical surface energies are mixed and used as the surfactant.

43. The method for producing a monomolecular liquid crystal alignment film according to any one of claim 40 or 42, wherein a terminal or a part of the carbon chain or the siloxane bond chain comprises at least one organic group selected from the group consisting of a carbon trifluoride group ($-CF_3$), a methyl group ($-CH_3$), a vinyl group ($-CH=CH_2$), an allyl group ($-CH=CH-$), an acetylene group

(triple bonds of carbon – carbon), a phenyl group (– C_6H_5), an aryl group (– C_6H_4 –), a halogen atom, an alkoxy group (– OR; R represents an alkyl group), a cyano group (– CN), an amino group (– NH_2), a hydroxyl group (– OH), a carbonyl group (= CO), an ester group (– COO –) and a carboxyl group (– COOH).

44. The method for producing a monomolecular liquid crystal alignment film according to any one of claim 40 or 43, further comprising the steps of washing the substrate with an organic solvent after the step of bonding and fixing the surfactant molecules to the surface of the substrate at one end, and tilting the substrate in a desired direction so as to drain off the solvent, thereby aligning the fixed molecules in the direction in which the solvent was drained off.

45. The method for producing a monomolecular liquid crystal alignment film according to claim 44 further comprising the step of exposing the substrate to light through a polarizing film after the step of aligning the molecules, so as to realign the molecules in a desired direction.

46. The method for producing a monomolecular liquid crystal alignment film according to claim 44 to 45, wherein a silane-based surfactant containing linear carbon chains or siloxane bond chains and chlorosilyl groups or isocyanate silane groups is used as the surfactant, and a nonaqueous organic solvent containing no water is used as the washing organic solvent.

47. The method for producing a monomolecular liquid crystal alignment film according to claim 46, wherein a solvent containing an alkyl group, a carbon fluoride group or a carbon chloride group or a siloxane group is used as the nonaqueous organic solvent.

48. The method for producing a monomolecular liquid crystal alignment film according to any one of claims 40 to 47, further comprising the step of forming a film containing a large number of SiO groups before the step of fixing the surfactant molecules at one end, and then forming a monomolecular film via this film.

49. A method for producing a liquid crystal alignment film comprising the steps of applying and forming a resin film transparent in a visible light range and having energy beam sensitive groups and thermoreactive groups on a predetermined surface of a substrate provided with electrodes directly or indirectly via an arbitrary thin film, and at least irradiating the resin film with energy beams through an arbitrary mask so as to react and crosslink the energy beam

sensitive groups.

50. The method for producing a liquid crystal alignment film according to claim 49, wherein the step of reacting and crosslinking the thermoreactive groups by heating is added before or after the step of reacting and crosslinking the energy beam sensitive groups.

51. The method for producing a liquid crystal alignment film according to claim 49 or 50, wherein the energy beam sensitive groups are photosensitive groups, and the resin film is irradiated with ultraviolet rays through a mask so that the photosensitive groups in the resin film react not only to crosslink between principal chains but also to align and fix side chain groups.

52. The method for producing a liquid crystal alignment film according to any one of claims 49 to 51, wherein a polarizing film or a diffraction grating is used as the mask for exposure.

53. The method for producing a liquid crystal alignment film according to any one of claims 49 to 52, wherein in the step of exposure, the resin film is exposed to light to an extent that concavities and convexities are generated on the surface thereof.

54. A liquid crystal display apparatus comprising a pair of substrates, electrodes and alignment films, the electrodes being formed on the surfaces of the substrates, the alignment films being formed thereon, liquid crystal being interposed between the counter electrodes on the two substrates via the alignment films,

wherein at least one alignment film is a film in which a silane-based surfactant having a linear carbon chain is chemically adsorbed via an energy beam sensitive film for generating a functional group containing active hydrogen by irradiation of energy beams, and the linear carbon chains are aligned in a specific direction.

55. A liquid crystal display apparatus, wherein a film is formed as an alignment film for liquid crystal directly on a surface provided with electrodes on at least one substrate of two substrates provided with counter electrodes or indirectly via another film, the film being a monomolecular film formed of a silane-based surfactant having linear carbon chains or siloxane bond chains, molecules constituting the film having a desired tilt and being bonded and fixed to the surface of the substrate at one end while being aligned uniformly in a specific direction, liquid crystal being interposed between the counter electrodes on the two

substrates via the alignment film.

56. The liquid crystal display apparatus according to claim 55, wherein said film is formed on each of the surfaces of the two substrates provided with the counter electrodes as the alignment film.

57. The liquid crystal display apparatus according to claim 55 or 56, wherein the film on the surface of the substrate comprises a plurality of patterned sections each having a different alignment direction.

58. The liquid crystal display apparatus according to claim 55, wherein the counter electrodes are formed on a surface of one substrate.

59. A liquid crystal display apparatus, wherein a film is formed as an alignment film for liquid crystal directly on a surface provided with electrodes of at least one substrate of two substrates provided with counter electrodes or indirectly via another film, the film being constituted by molecules containing carbon chains or siloxane bond chains, a part of the carbon chain or the siloxane bond chain containing at least one functional group for controlling a surface energy of the film, liquid crystal being interposed between the counter electrodes on the two substrates via the alignment film.

60. The liquid crystal display apparatus according to claim 59, wherein said film is formed on each of the surfaces of the two substrates provided with the counter electrodes as the alignment film.

61. The liquid crystal display apparatus according to claim 59 or 60, wherein the film on the surface of the substrate comprises a plurality of patterned sections, each having a different alignment direction.

62. The liquid crystal display apparatus according to claim.59, wherein the counter electrodes are formed on a surface of one substrate.

63. A liquid crystal display apparatus, wherein a resin film transparent in a visible light range and having energy beam sensitive groups and thermoreactive groups is formed directly on electrodes or indirectly through an arbitrary thin film, and at least the energy beam sensitive groups are reacted and crosslinked, the thus obtained liquid crystal alignment film being formed on electrodes on at least one substrates of two substrates provided with counter electrodes, liquid crystal being interposed between the counter electrodes on the two substrates via the resin film.

64. A method for producing a liquid crystal display apparatus comprising the

steps of applying and forming an energy beam sensitive resin film for generating functional groups containing active hydrogen by energy beams directly or indirectly via an arbitrary thin film on a first substrate including first electrode arrays arranged in a matrix beforehand, irradiating the surface of the resin film with energy beams in an arbitrary pattern, contacting the substrate with the irradiated resin film with a chemisorption solution containing a silane-based surfactant having linear carbon chains and Si, washing the substrate with a solvent incapable of dissolving the resin film so as to form one layer of a monomolecular film formed of the surfactant selectively in the irradiated portion, and aligning and fixing the linear carbon chains, attaching the first substrate including the first electrode arrays to a second substrate including second electrodes or electrode arrays so that the respective electrodes are opposed with a predetermined gap, and injecting predetermined liquid crystal between the first substrate and the second substrate.

65. A method for producing a liquid crystal display apparatus comprising the steps of contacting a first substrate including first electrode arrays arranged in a matrix beforehand with a chemisorption solution directly or after forming an arbitrary thin film so as to cause a chemical reaction between the surfactant molecules in the adsorption solution and the surface of the substrate, thereby bonding and fixing the surfactant molecules to the surface of the substrate at one end, washing the substrate with an organic solvent, tilting the substrate in a desired direction so as to drain off the solvent, thereby aligning the fixed molecules in the direction in which the solvent is drained off, exposing the substrate to light polarized in a desired direction through a polarizing plate so as to align the orientations of the surfactant molecules uniformly in a specific direction at a desired tilt, attaching the first substrate including the first electrode arrays to a second substrate or a second substrate including second electrodes or electrode arrays so that the faces provided with the electrodes are facing inward with a predetermined gap, and injecting predetermined liquid crystal between the first substrate and the second substrate.

66. The method for producing a liquid crystal display apparatus according to claim 65, wherein in the step of exposing the substrate to light polarized in a desired direction through a polarizing plate so as to align the orientations of the bonded surfactant molecules uniformly in a specific direction at a desired tilt, the

step of exposure with a patterned mask disposed on the polarizing plate is performed several times so as to form a plurality of patterned sections each having a different alignment direction on one face of the alignment film.

67. A method for producing a liquid crystal display apparatus comprising the steps of contacting a first substrate including first electrode arrays arranged in a matrix beforehand with a chemisorption solution directly or after forming an arbitrary thin film, the chemisorption solution being produced by using a silane-based surfactant containing carbon chains or siloxane bond chains, at least a part of the carbon chain or the siloxane bond chain containing at least one functional group for controlling a surface energy of a formed film, so as to cause a chemical reaction between the surfactant molecules in the adsorption solution and the surface of the substrate, thereby bonding and fixing the surfactant molecules to the surface of the substrate at one end, washing the substrate with an organic solvent, tilting the substrate in a desired direction so as to drain off the solvent, thereby aligning the fixed molecules in the direction in which the solvent is drained off, attaching the first substrate including the first electrode arrays to a second substrate or a second substrate including second electrodes or electrode arrays so that the faces provided with the electrodes are facing inward with a predetermined gap, and injecting predetermined liquid crystal between the first substrate and the second substrate.

68. The method for producing a liquid crystal display apparatus according to claim 67, further comprising the step of exposing the substrate to light polarized in a desired direction through a polarizing plate so as to align the orientations of the surfactant molecules uniformly in a specific direction at a desired tilt after the step of aligning the fixed molecules.

69. The method for producing a liquid crystal display apparatus according to claim 68, wherein in the step of exposing the substrate to light polarized in a desired direction through a polarizing plate so as to align the orientations of the bonded surfactant molecules uniformly in a specific direction at a desired tilt, the step of exposure with a patterned mask disposed on the polarizing plate is performed several times, thereby forming a plurality of patterned sections each having a different alignment direction on one face of the alignment film.

70. A method for producing a liquid crystal display apparatus comprising the steps of applying and forming a resin film transparent in a visible light range and

having energy beam sensitive groups and thermoreactive groups directly or indirectly via an arbitrary thin film on a first substrate including first electrode arrays arranged in a matrix, at least irradiating the resin film with energy beams through an arbitrary mask so as to react and crosslink the energy beam sensitive groups, attaching the first substrate including the first electrode arrays to a second substrate including second electrodes or electrode arrays opposed to the first electrode arrays so that the respective faces provided with the electrodes are opposed to each other, and injecting predetermined liquid crystal between the first substrate and the second substrate.